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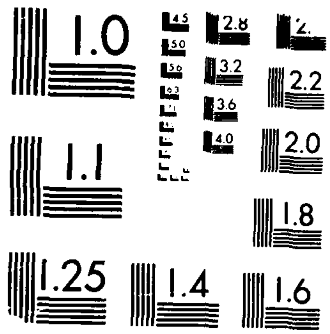

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AIR COMMAND
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STUDENT REPORT

USE OF OPTICAL DISK TECHNOLOGY
AT THE AIR COMMAND AND STAFF COLLEGE

MAJOR CURTIS H. ARRINGTON III 88-0130

"insights into tomorrow"

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TITLE USE OF OPTICAL DISK TECHNOLOGY AT THE AIR COMMAND AND STAFF COLLEGE

AUTHOR(S) MAJOR CURTIS H. ARRINGTON III, USAF

FACULTY ADVISOR MAJOR JIM GATEWOOD, ACSC/EDT

SPONSOR LT COL JIM MACEY, ACSC/EDT

Submitted to the faculty in partial fulfillment of requirements for graduation.

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Optical disk technology, the use of lasers to store and retrieve information, is a growing technology for use in audio, video, computer storage and multi-media applications. This technology has a great potential in educational applications. After reviewing the history of information capture and storage, this paper examines how optical disk technology works, its capabilities and limitations. The paper reviews current and potential educational applications, and matches ACSC technology requirements against the potential of optical disk. The paper concludes that optical disk is a viable technology to meet several ACSC requirements and recommends the acquisition of optical disk systems for use in specific applications.

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PREFACE

This paper examines an exciting new area of technology, optical disk, which uses lasers to store and retrieve information. This technology is being applied today in audio systems, video systems, and computer systems. After examining information storage history and the basics of laser optical disk technology, this paper specifically examines educational applications and the potential for use of optical disk in the Air Command and Staff College (ACSC) environment. The concept for this paper was generated by a request for research assistance from the Educational Technology Division at the college. The avid interest of Lt Col Jim Macey and Maj Jim Gatewood in using new technology to improve the ACSC educational environment inspired and directed this research. The paper should form the basis for future technology plans and specific programming, budgeting, and acquisition actions to enhance the technology support at ACSC.

ABOUT THE AUTHOR

Major Curtis H. Arrington is a career Air Force officer with fourteen years experience in a variety of data processing and data communication environments. He holds a Bachelor of Science in Computer Science from the University of Southwest Louisiana, and a Master of Computing Science from Texas A & M University. He is a data base management system specialist, with design and implementation experience in large and very large databases on IBM, Honeywell, and Burroughs mainframe systems. He is a software engineer and software project manager, with experience in large, multi-user, teleprocessing applications. He has developed software in a variety of application areas, including aircraft simulation, personnel, training management, and logistics. Major Arrington has held positions of responsibility at Strategic Air Command Headquarters, the Air Force Manpower and Personnel Center, and Field Command, Defense Nuclear Agency. He has attended a variety of technical and professional schools, including Squadron Officers School in residence. He is currently attending the Air Command and Staff College at Maxwell AFB, Alabama.

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EXECUTIVE SUMMARY

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AUTHOR(S) MAJOR CURTIS H. ARRINGTON III, USAF

TITLE USE OF OPTICAL DISK TECHNOLOGY AT THE AIR COMMAND AND STAFF COLLEGE

I. <u>Purpose:</u> To investigate the capabilities and limitations of optical disk technology and determine its applicability in meeting information management technology requirements at the Air Command and Staff College (ACSC).

II. <u>Problem:</u> The faculty and staff of ACSC have requested a variety of technological innovations to support and enhance the educational environment at the college. These requirements cover a wide spectrum of audio, video, and textual applications. A new technology, optical disk, has been touted to support many of these applications. Is this emerging technology a viable, effective way to meet ACSC requirements?

III. <u>Discussion:</u> In the last 40 years, information storage technology has exploded onto the scene. With the birth of the computer age, the ability to store and process vast amounts of data has become part of our professional and private lives. Audio and video technology has also come on the scene, with wide-

spread usage of records, tapes, slides, television, and video tapes in our homes and in our professions. Optical disk, developed over the last 10 years, is a technology which uses lasers to record information at extremely high densities on a small platter. This platter can be reproduced at very low cost, and the information can be retrieved using a low-cost laser reader. The current creation process for the master disk is expensive (up to $10,000), but new, user-updatable systems are lowering this cost considerably. Reproduction cost is less than $10 per copy for a disk which can hold 150,000 printed pages. This technology, coupled with the information processing capabilities of the computer, was first used in video recording. Its most popular application has been in Compact Disk (CD) audio recordings, and has recently been used as a computer database storage device. Storage capacity of optical disk is ten to hundreds of times that of the equivalent size magnetic storage medium. The media used in the reproduction process is very rugged. It can be handled without damage, and is not affected by magnetic forces. One of the nicest features of optical disk is that audio, video, and textual information can be stored on the same disk, providing flexibility and enhancing creativity in the development of multimedia presentations. Optical disk is being used in many educational applications today, and the potential of the media is just beginning to be realized. It has been used to replace audio and video tape libraries, to store and manipulate maps, and to hold very large research data bases. Optical disk has great applicability in tutorial systems, simulations, standardization data bases, and authoring system support. Many of these applications correspond directly to ACSC technology requirements. The college needs improved audio/visual support, war gaming and simulation capability, curriculum development tools, research support systems, and self-paced tutorial systems. Audio, video, and textual data needs to be accessible through the computer systems available at the college.

IV. Conclusions: Optical Disk technology is currently a viable alternative to meet many of the audio, video, and textual information storage requirements at ACSC. The cost of creating a master disk is coming down, and low reproduction cost makes optical disk a very economical storage media for audio, video, and high-volume computer data bases. The use of optical disk technology, in conjunction with appropriate software on the college's computer systems, can create an educational environment where slides, videos, maps, voices, music, sound recordings, and large volumes of textual and numeric data can be integrated into a variety of enhanced educational tools. The technology is still

being developed, with advances in capability, capacity, and flexibility occuring frequently. The capabilities of this information storage technology are just beginning to be used. The potential of optical disk is limited primarily by the knowledge and imagination of the user.

V. Recommendations: ACSC should quickly acquire a small optical disk system for staff education, capability demonstration, and prototyping. ACSC should plan, fund, and acquire optical disk systems to replace or supplement current audio/visual systems, to store, display, and distribute maps, to build research support systems, and to support administration, word processing, and curriculum development systems. ACSC should consider optical disk systems for all future technology projects which require audio/visual support or very large computer data bases.

Chapter One

INTRODUCTION

This paper examines a promising new area of technology and its application to the educational environment, with particular emphasis on application at the Air Command and Staff College (ACSC). The technology, grouped for the purpose of this paper into a generic category called optical disk, is still in its infancy. Less than ten years old, it combines the characteristics of metallics, lasers, optics, digital circuitry, and computers into a powerful, high-capacity memory device (1:56-63). In the brief period since its introduction in 1978 (10:162), this technology has been used to support applications ranging from business to navigation, from medicine to Greek literature. The "possibilities" for use in the field of education, according to one source, are "endless" (16:696). This paper will explore those possibilities and their applicability to the ACSC environment.

To accomplish this task, this paper will establish a general knowledge base on information storage, provide specifics on optical disk technology and its educational applications, and then look in detail at potential uses at ACSC. To form that general knowledge base, Chapter Two summarizes the history of information storage technology. It describes many of the methods man has used to record information throughout history, from the early writing materials of the ancient Egyptians to the variety of media used in the modern world of computers. Chapter Three provides detailed information on optical disk technology: how it works, the capabilities and limitations, the types of products, and the current and future directions for development of this technology. Chapter Four highlights some of the current uses of optical disk in various educational settings, the advantages that can be gained, and potential for future uses. Chapter Five lists documented requirements for technology enhancements at ACSC where the use of optical disk technology could be beneficial. Chapter Six summarizes the conclusions of this research and recommends specific areas for future evaluation and use of optical disk technology at ACSC.

Chapter Two

INFORMATION STORAGE HISTORY

In a very real sense the history of civilization, man's ability to deal with others in a rational manner, has been the history of information technology. Written records probably began on animal skins, but the development of papyrus by the Egyptians in approximately 3500 BC (15:51) led to the first systems of written records. Hand-written records were the format for information for nearly five thousand years. The expense of hand copying information greatly limited its availability. The educational and informational needs of the masses had to wait until around 1450 AD, when Johann Gutenberg developed a printing press which worked with movable type (13:238). Over the next several hundred years the printed word exploded across the world. Books formed the basis of our education system. Newspapers and magazines were developed, bringing people information in a cheap, disposable form. In the early 19th century a new form of information was made available to people through the ability to record light -- photography (11:311).

As the technology of photography has grown, pictures have enhanced our education systems, adding a new dimension to books and periodicals as well as providing new tools for scientific research. Motion was first captured in the early Hollywood movies, and this capability expanded into the modern world of television and video tape. Moving pictures were greatly enhanced by another scientific development -- the capture of sound.

Thomas Edison first recorded "Mary has a little lamb" in 1877 (9:305). Over the last hundred years audio technology has added sound to motion pictures, created the music industry, and made it possible to record not only "what" was said, but "how" it was said. Pace, tone, and context often contain as much information as the words themselves. Clearly the recording of audio signals has contributed to the rapidly growing variety of information sources available in the modern world.

The rapid growth of information media has led to the development of systems for managing information for the use of people. Library systems have grown for books and periodicals, as well as collections of pictures and sound recordings. Finding information in a library can be a very time consuming task, even

with the help of card cataloging systems. A major problem is the media itself -- it takes up space. Libraries are huge buildings, with sometimes acres of books. Records, tapes, and film also have storage problems. Another problem is finding a particular piece of information in a larger collection, e.g. a book or recording. Some form of indexing is required to identify subject matter within the information collection. To solve the problems of time, space, and intelligent access, man has turned once again to technology -- the computer -- and the mass storage media which have been developed to support the computer.

The computer uses speed to provide man with access to information at an unprecedented rate. First at electromechanical speeds, then electrical circuit speeds, and now in millionths of a second using large-scale integrated circuits, a computer can access and process data in its electronic memory. Cost, volatility, and capacity limit internal memory, however, and computer systems have always required external memory to hold large amounts of data. Early external devices, like paper tape and punch cards, provided some capacity but were very slow, required lots of manual processing, and were subject to physical problems such as jamming (3:672-676). Cards were machine-readable, but did little to solve space and storage problems associated with textual material. The first high-capacity, low-cost mass storage media developed to attack these problems was magnetic tape.

Magnetic tape proved to be a relatively low-cost, high-capacity medium for storage of machine-readable data. Technology quickly moved tape density (which equates to capacity) from 555 bits per inch (bpi) to 800, 1600, and 6250 bpi (10:161). With a standard reel holding 2400 feet of tape, at 6250 bpi one reel can theoretically hold one hundred and eighty million characters, or over thirty-seven thousand pages of text. The problem with magnetic tape, however, is that it is a linear, or sequential format. Finding a particular piece of information can take up to a minute. This time is far too slow for computer programs which are working in nanoseconds, and is also unacceptable for processes which are working with humans. For most interactive systems ten to fifteen seconds is considered a long response time (2:61). What was needed was a device with random access capability.

The development of magnetic disk met this need for faster access (10:161). With data stored on rapidly spinning platters, a short movement of the reading mechanism and a short wait for the platter to revolve resulted in access times of well under a second. Capacities for disk drives have grown to hundreds (in some cases, thousands) of millions of characters (4:47). Size, cost, and the fixed format, however, limit the availability of this technology for the micro computer users of today.

Floppy disks provided system designers with a cheap, removable, random-access methodology which met the requirements of the relatively simple single-user micro system (10:161). As micro systems get more complex, however, several problems with floppies become apparent. First, capacity is limited. Standard formats range from 320,000 to around 1.2 million bytes (4:47). Second, they are slow. Access times are not near those of hard disks, and time delay results from the manual changing of floppies when only one or two drives are available. The biggest problem with floppies remains reliability. The technology encourages wear and tear. The read head physically contacts the media, and friction and wear can make a floppy unreadable. Dirt and finger prints provide other hazards. Micro users are turning to higher capacity, faster, safer options such as Bernoulli disks and Winchester hard drives to defeat these problems (10:166).

The developments in computer storage discussed to this point have been primarily designed to hold character data in digital format. This format is good for text or numbers, and the industry has taken advantage of this capability. Business and government managers literally have access to more information than they can intelligently handle. Virtually untapped in information processing circles, however, is the tremendous informational content of the audio and video media. One reason for this is the high capacity requirements for storage of audio or video signals in a digital format. Even given the high capacities of fixed disks, economical audio and video systems are beyond their capability. With the seemingly ever-increasing growth in textual and numerical requirements, the increasing sophistication of computer software, and the desire to utilize audio and video information, engineers continue to search for higher capacity, faster, random access media to support future information systems. One very promising development is the application of optical disk technology to storage and retrieval of textual, audio, and video information.

Chapter Three

OPTICAL DISK TECHNOLOGY: CHARACTERISTICS, CAPABILITIES, LIMITATIONS

Over the past ten years a distinctly new information storage media has become available. This new media is a radical departure from most computer-accessible media. It uses light rather than magnetism to store and retrieve data. The technology is based on recording large volumes of information on a master disk in a series of tiny "pits", which are actual depressions or scratches on the coating of the master. This is done by focusing a high-powered laser onto the surface (1:58). Once the master is created, copies can be created out of molded plastic at very low cost (10:162). The "pits" on the copies can be detected by a tightly focused laser in a relatively cheap reader or player (1:51). This technology, variations of which are all based on laser manipulation of the media, is known by several of labels: Optical Disk, Laser Disk, Video Disk, Compact Disk (CD), Compact Disk - Read Only Memory (CD-ROM), Compact Disk Video (CDV), Compact Disk Interactive (CDI), and Write Once Read Many (WORM) (7:46-47). The many names represent the current condition of the industry -- rapid growth, a variety of applications, and a number of standards for different applications which tend to confuse both the potential user and the industry itself. Despite this confusion, optical disk technology has shown tremendous potential during its brief history.

The first optical disk systems were developed for the television industry to record programs for playback. These systems used molded plastic disks which recorded video signals in an analog, frequency-modulated (FM) format. Each disk was capable of holding one hour of broadcast-quality video on each side. The information holding capacity of these disks went far beyond the floppy or fixed disk platters. The tight focusing capability of the laser reader allowed for a spacing between recording tracks of 1.6 micrometers, at least ten times closer than magnetic disks. This equated to nearly sixteen thousand tracks per inch (10:162). Data storage was also denser. The "on" state, the equivalent of a "1" bit in magnetic digital recording, was indicated on the track by creating "pits", scratches or depressions, which could be detected by the laser reader. This methodology provided a recording density of approximately 35,000 bits per inch (bpi), which when combined

with the higher track density, resulted in several hundred times the capacity of floppy disks and more than 20 times that of today's fixed magnetic disks (12:144).

Usable capacity depended on the recording format. Higher volume could be obtained using constant linear velocity (CLV), in which the drive turned the media at a varying velocity depending on where on the disk it was reading. This allowed for the same density of information to be recorded on all tracks (1:52). In simple terms, this means that on the longer tracks (outside of platter) the drive goes slower, and on the shorter tracks, the drive goes faster. This format allowed up to 60 minutes of video on each side. Constant angular velocity (CAV) format used a constant speed for the drive and recorded the same amount of information on each track. This meant that each track was limited to the capacity of the shortest (inside) track (1:52). In practice, this meant that approximately 54,000 tracks per side held 1 video image on each track, cutting total viewing time to 30 minutes. However, since using CAV meant that the location of each image on the disk was known (i.e., one on each track), random access was possible (1:52). One can locate any image exactly on the disk easily, permitting indexing of various parts of a recording. These capacities and capabilities attracted the television industry, and several commercial versions were developed.

The major commercial standard system was know as LaserVision, produced by manufacturers such as Phillips and Pioneer. First introduced in 1978, these systems have been improved over the years and the cost has been reduced. LaserVision uses a twelve or eight-inch disk to hold video and audio information (1:52). Some manufacturers have incorporated digital data onto a LaserVision format, converting digital signals to an analog form which looks like a video signal. These systems have capacities up to 1 gigabyte (1,000,000,000 characters) and are used today primarily in applications which require both television video and digital data (1:53). With the cost of players now down to between $250 and $1,500, they are becoming a viable alternative to films and books, particularly in the educational environment (16:696). Perhaps LaserVision's largest contribution to information management was to set the stage for the next major development in use of optical disk technology: the digital audio disk.

The availability of optical disk technology for use by the general public burst onto the scene in 1983 with the development of the Compact Audio Disk (CD). What in theory are miniaturized versions of LaserVision disks, CD's provide very high-quality audio sound in a compact, rugged form. On a four and three-quarter inch disk, up to 74 minutes of audio can be recorded per side (10:162). Since the disk is plastic and read

with a laser, as opposed to a phonograph record or tape which requires the reading mechanism to contact the media, the quality of the sound is not only better (1:273) but very long-lived. The mass appeal of this format has been amazing. The cost for a player, prohibitive at over $1000 as late as 1984, is now less than $150 in any local audio store. In the first two years, more than 65 million CD's were sold (1:51). The technical differences between CD's and LaserVision disks, namely digital recording and the introduction of error correction coding, made this a potential candidate for use by the computer industry for storage of digital data. Recognition of this potential led to the development of the Compact Disk - Read Only Memory (CD-ROM) (10:162).

CD-ROM, as an outgrowth of the audio CD industry, is based on the same technology. As in most rapid growth technical arenas, various methods to store and retrieve data (formats) have been used by various system developers. The big computer companies have tried to develop standards to enhance compatibility, but the real standard has been generated by the big manufacturers of CD equipment, Sony and Phillips. They license the use of these standards to various firms for a fee of $25,000 (7:48). The CD-ROM standard storage methodology allows for at least 550 megabytes of data (1:47). CD-ROM also includes stringent error detection and correction techniques. Unlike its audio and video counterparts, accurate data is very important in computer data bases. Audio and video players can replay or skip blocks of data in error, and the human senses (hearing and vision) won't detect it. Computers, however, depend on each byte of data to be accurate, as a single error could prove disastrous. An acceptable error rate for computer data storage devices is 1 error in 10,000,000,000,000 bytes (1:73). CD-ROM provides error detection and correction capability that meets or exceeds this standard (11:65). This high-volume, low-error capacity is the key to the capabilities of CD-ROM (1:47).

The capacity of one disk is phenomenal. When translated into familiar examples, it truly boggles the mind. One disk can hold over 150,000 pages of text, images of more than 15,000 documents (two filing cabinets full), the equivalent of more than 1200 floppy disks, or eight hours of educational presentation consisting of high quality pictures and 10 seconds of narration for each picture (1:47). All this on a disk less than 5 inches across, which costs less than 10 dollars to produce in mass (4:47). This capacity-to-cost ratio offers huge advantages for the transfer of large amounts of data for computer system users. For example, to transfer the content of one CD over commercial phone lines at 1200 baud would take 46 days of continuous data transmission (14:68). Capacity supports another great capability of CD-ROM, the ability to locate data.

The capacity of the CD-ROM allows for storage of large indexes as well. This capability ranges from simple indexing of subjects, authors, and titles, (similar to a card catalog) to "total inversion" of the data, meaning that each word is indexed and can be retrieved independently. This capability greatly enhances the user's ability to search for occurrences of keywords, either alone or in combination with other keywords (1:131). Indexing, along with appropriate file structuring techniques, make the large capacity of the CD-ROM manageable for users. With CD-ROM players costing as little as $500, these devices are growing in popularity for large capacity applications. Large databases on CD-ROM are a reality today (14:68), and additional functionality is just around the corner (1:273-294).

One near-future application of CD technology is CD Interactive. Under computer control, pre-recorded audio, pictures or combinations can be accessed and presented to the computer system user (1:274). System designers have long desired an audio interface, and have tested voice synthesis as one method. CDI can provide full stereo sound, voices, or sound effects to enhance the interface with the user. Graphics and pictures can be presented (1:286). These capabilities will provide a much "friendlier" interface for computer applications such as entertainment or educational systems. One area that the CD format doesn't handle well right now is video, but CD video is not far off (1:294).

As stated earlier, the first use of optical disk technology was for recording analog video signals. CD format, however, is digital, and is not nearly as efficient in storing video as the early optical disk systems. One second of digital color video requires about 30 megabytes of storage, compared to the equivalent analog storage of approximately 1 megabyte (1:291). A CD player's transfer rate is also too slow, less than one-third the rate required to transfer video (1:291). The key to CD Video is coming on the scene today: digital video. Digital TV is already available on the market. Each video frame is "captured, compressed, and stored as a 64k-byte buffer in the television" (1:293). Special computer chips perform the compression and decompression. This development, along with an old data base technique of storing only the changes to a frame, will, in the near future, make CD Video a reality (1:280).

The advantages of optical disk technology are many: large capacity, practically indestructible in standard use, and very flexible in the types of information they can store (1:47). What are the disadvantages, the drawbacks? First, optical disk technology is currently a read-only format. Disks are produced with expensive mastering equipment (about $10,000 for a CD-ROM master (1:24), and only readers are sold at a price affordable

for most users. Disk production will become possible for many more users, however, as the Write Once Read Many (WORM) technology comes on line. This methodology, first introduced in 1983, has produced drives which cost less than $5000 for mastering disks. This improvement may be followed quickly by alterable disks, based on new materials being used in the recording media which can be altered and returned to original state by laser excitement (10:168). Another drawback is access speed. Although search algorithms on CD-ROM are optimized when using large stored indexes, actual radial access time (the time for read head movement) and latency (rotation time) are slow in comparison with hard disks. In fact, CD-ROM access time is closer to floppy disks than hard disks (4:47). Queries which require large volumes of data retrieval will be slower than hard disk systems. This is a real problem for a medium with capacity far beyond either floppy or hard disk systems (1:51).

Despite these drawbacks, the future for optical disk technology, particularly CD-ROM and its audio and video cousins, is promising. The primary reason is cost (10:169). In this day of giant computer data bases and large numbers of microcomputers, economical distribution of large amounts of information is a continuing requirement (2:11). Shipping recorded CD data across the country by courier costs less than 2 cents per megabyte. This is 100 times cheaper than current satellite or microwave communications, and nearly 10,000 times cheaper than modem communication over direct-dial phone lines (10:169). This fact alone will make optical disk storage a viable medium for both large system and personal computer users in a variety of business, government, and education applications.

Chapter Four

EDUCATIONAL APPLICATIONS OF OPTICAL DISK TECHNOLOGY

As described in Chapter Three, optical disk technology is a growing technology which is not only powerful but, because of its multimedia capability, is very versatile. The educational community (teachers, school systems, colleges, universities, libraries, government and private training programs, and publishers) are beginning to explore the potential of this technology. The very large storage capacity, low cost of reproduction, and quick search capability make optical disk systems a candidate for a variety of educational applications (8:19). This chapter will explore some of the current educational applications, as well as proposed uses of the potential of optical disk technology.

Replacement of film and video tape libraries is one of the most obvious applications of optical disks. Sixteen millimeter films are expensive ($250-$700) and easily damaged or broken. Projectors are a maze of pulleys, belts, and sprockets; hard to use and requiring constant maintenance (16:697). Video tapes are subject to wear and, due to the linear nature of the media, can't be searched efficiently. The quality of audio and video on tape is not as good as on optical disk (16:699). In contrast, current videodisk (and potentially CD-ROM) systems are easier to use, practically maintenance free, use a wear-free media, and are much cheaper than either film or video tape systems (16:697,699). A variety of titles are available, ranging from children's movies to documentaries such as "World at War" (16:698).

Optical disk is a potential prime media for storage, display, and manipulation of maps. Once defined as "a geographical representation of a portion of the earth's surface" (5:129), maps can now be stored as "pictures" or converted to digital representation which computers can manipulate. CD-ROM's large capacity and cheap reproduction cost, coupled with the capability of the computer to manipulate data, provide for a variety of map applications (1:553). Educational applications range from simple replacement of paper maps with video images to highly interactive computer simulation systems which can build three dimensional images of a portion of the earth's surface. Pctential uses range from elementary geography courses to realistic simulators used in military training programs. The U.S. Army uses optical disk in

tank simulators (16:699) as a cheap alternative for actual use of combat vehicles. Digitized maps on optical disk, coupled with computer power, can put maps of varying scale in the hands of the user (1:547). With this tool, a teacher could, for example, start with a large scale map of Europe and explain movements of Napoleon's armies. With a few keystrokes, the display could zoom in on a particular campaign area, and finally produce a detailed map of the terrain at Waterloo. The teacher could "draw" on these maps with computer graphics tools, without destroying the map as you would with a paper copy. This scenario is but one of many potential uses of Optical Disk, particularly CD-ROM, an ideal storage media for future uses of cartographic databases (1:563).

Another educational use of Optical Disk technology is in library and reference material applications. A variety of reference works, with search indexes, have been put on compact disk. The storage capacity, as in other optical disk applications, is staggering. The Encyclopedia Britannica has been stored on one compact disk (14:68). Reference works, consisting of still images and text, cover a wide range of subject matter. A Bioscience disk, with 6,000 images of plants and animals, could be a standard reference in every Biology classroom (16:697). Sample history applications include the Vietnam War, general history since World War II, and the history of aircraft and space (16:698). Classical Greek Literature has been put on compact disk, in Greek and English, for use by scholars at Brown University (1:577). Users include authors of classical texts as well as occasional users from fields such as religion, archaeology, linguistics, and philosophy. Other research databases have been created for Medical applications, Chemical Engineering, and Aeronautics (14:68). Perhaps one of the most ambitious projects using optical disk is being done at the Library of Congress. They are conducting a three-year pilot program to distribute catalogs on disk, including authors, subjects, and music (1:519-521). The expanding number of optical disk reference materials has resulted in the publication of directories for use by researchers, listing databases and products available on disk (14:69).

Optical Disk technology has tremendous potential as a self-paced educational tool (16:698). When coupled with the personal computer, video and audio disk open up a whole new world of instruction known as Computer Assisted Videodisk Instruction (CAVI). CAVI combines the capabilities of slides, films, television, stereo, and the personal computer into a powerful multimedia tool (16:698). In addition to presentation capability, the student can query the computer for explanation or expansion of a concept and get in return not only textual information but pictures, a short video segment, or an oral explanation. Entire courses of study, including lectures,

slides, short film clips, readings, and music can be stored on one disk (16:699).

Another high potential educational use of CD-ROM is to develop and distribute test-item data bases (8:17). Teachers in schools across the country independently develop test questions on the same subjects, a timely and difficult task. By developing data bases of high quality test questions, much of the redundancy of this task could be eliminated. This type of system would also contribute to the consistency of tests and curriculum across the educational system. The read-only nature of optical disk systems, where users have only a play-back capability, contributes to the security requirements of sensitive test-item databases (8:17).

The authoring and publishing potential of optical disk technology will support many educational environments. The ability to combine audio, video and text with the powerful search capabilities of CD-ROM systems will challenge the authors of future educational material. The potential exists to create interactive systems which allow the user to browse through a variety of material, then follow a particular subject into greater detail, view pictures and hear sounds which enhance his understanding, then quickly jump to another subject area triggered by something he saw in one of the pictures (6:25). A major challenge for future authors will be to understand and employ the flexibility of this media using video, background music, voice narration, and textual material. Future authors must avoid the temptation to use the capacity to produce several hundred thousand pages of textual material, ignoring the potential of the other, more impactive forms of communication (6:26).

This list of educational applications could continue for some time, examining the potential use of the massive capacity, low cost, and great flexibility of optical disk technology. Opportunities for use exist in such varied areas as student records, image processing, and nationwide curriculum standardization. Audio and visual presentations could replace chemistry experiments or biological dissections (8:15). Some of these applications are in being today, and many are technically feasible today. As Write-Once Optical Disk and Updatable Optical Disk systems become economically accessable to the small user in the near future (10:168-169), users will have flexibility to build or modify optical disk databases. The combination of the computer with the flexible storage capabilities of optical disk will stretch the imaginations of authors, publishers, and educators who step into this new world of vast potential (6:27).

Chapter Five

AIR COMMAND AND STAFF COLLEGE REQUIREMENTS FOR OPTICAL DISK FUNCTIONALITY

The Air Command and Staff College has begun the process of applying new technology to the educational environment. Students at the college are exposed to a variety of informational sources, primarily textual information, lectures, or video tapes. Personal computers and associated software have been introduced into the student and faculty environment in a stand-alone capacity. Support facilities for the college include the Air University Library and the Air University Audio Visual Center. During the research period for this paper, the ACSC faculty and staff were developing a Technology Plan which identifies requirements for a variety of technological enhancements to support the educational mission of the college out to the year 2000. Inputs were solicited from all Directorates at the college, and formed the basis for the requirements identified in the plan. Requirements varied from simple computer literacy training through more complex interactive teaching aids up to long-range requests for expert systems and war gaming simulations. This plan (17:--) and the directorate inputs for the plan are the primary sources for the material in this chapter. Information from other sources is identified by reference. This chapter will identify those specific ACSC requirements where, in the opinion of this researcher, the use of optical disk technology is of potential benefit.

The most immediately identifiable area for use of optical disk technology is in improving basic audio/visual support. A variety of requirements have been identified, ranging from the quality of presentations in the college auditorium to availability of presentation aids in the classroom. Current audio/visual support is provided through various media including slides, viewgraphs, overhead projectors, and film or video tape. Classrooms have television monitors which can display recorded presentations (primarily video tape) or can echo the display of the classroom personal computer. Air University (AU) has a large video tape library which supports ACSC as well as the rest of the AU community. The high quality, low cost capability of videodisks (and in the near future, CD-ROM) is a viable alternative to the current video tape capability, and has the potential to support other audio/visual requirements as well.

When coupled with a computer system, optical disk could form the basis for war gaming and simulation capabilities identified in the technology plan. The large data storage capacities required for such systems are well satisfied by optical disk. Adding realism factors such as terrain maps, simulated aircraft video and audio, etc. would certainly enhance these systems, and optical disk is an ideal format for such data.

The need for curriculum development tools was identified in the plan. Optical disk databases, containing a variety of video images, audio images, charts, graphs, and text, could form the basis for such a system. Cheap to reproduce, a set of standard optical disk databases could be given to each individual involved in curriculum development. The powerful indexing capability of optical disk systems could provide an easy cross reference and topic search facility. Using this database as a basis for development, with the appropriate computer software, the author could select various segments for his project, "cutting and pasting" text, video, and audio segments as required.

Perhaps the largest potential use area for optical disk is research support, both for curriculum development and student and faculty research projects. A large variety of potential applications have been identified. Access to many USAF, DOD, government, and commercial databases has been suggested. CD-ROM, as detailed in Chapter 2, is an ideal low-cost method of distributing large databases. Storage of and access to historical databases on college information, such as student demographics, student critiques, and test results, could easily be done with optical disk systems. When the video and audio capability of CD-ROM is available, a research database of video recordings (lectures, speeches, seminars) could be developed. With the powerful indexing and access capabilities of CD-ROM, all of these databases could be searched to provide cross-reference, topic, or keyword association.

Maps play a large part in the student curriculum, used in student seminars for everything from military history lessons to manually-simulated war games. To support these activities and a variety of research applications, the Cartographic Information Center at the Air University Library maintains over 600,000 maps, charts, and related publications (18:3). Determining what is available, despite the best efforts of the staff, is a time consuming and sometimes exasperating task. Thousands of copies of maps are given away each year for students to use for presentations. High cost maps must be "signed out" on a hand receipt, and accounted for. Given the capacity of 54,000 video images on a videodisk (16:697), it would be possible to keep a copy of the entire map room on 11 disks, easily storable in each seminar room for student use. The map images would be computer accessible through an index structure. Graphics tools could be

computer accessible through an index structure. Graphics tools could be used to modify copies of the maps, for example to illustrate the concepts of Air Land Battle in a particular geographic area. These modified copies could then be electronically "thrown away" after use, at no cost to the taxpayer.

Databases of writing formats, such as the Air Force standards found in AF Pamphlet 13-2, Tongue and Quill, and standard ACSC forms could be stored on optical disk. In fact, given the immense storage capacity available, it is very feasible that a database of every standard DOD, USAF, and MAJCOM form, letter format, and style guide could be indexed and stored on one disk. Effective writing instructors could customize courses for their students. Secretaries would have all required formats available immediately, or students could even fill out their own forms on the personal computers in the seminar rooms.

Interactive tutorial support for individual students, as envisioned in the technology plan, will require the large storage capacity and indexing capability of optical disk (probably CD-ROM) coupled with the power of the personal computer. As described in one directorate's input, the system would allow the student to skim material at the level of detail desired, with the ability to change levels of detail for particular areas of interest. ACSC covers a variety of subjects at an introductory level, and ecourages students to probe deeper into areas which they have special interest. Potential in-depth tutorial subjects range from the Joint Operational Planning System to how to use the computer software on the school personal computers.

These are major applications at ACSC, primarily from the ACSC Technology Plan, which could utilize the capabilities of optical disk technology. They have in common the requirement for very large amounts of data which is primarily static in nature. They incorporate the desire to use audio, video, and textual data to enhance the learning environment at ACSC. Optical disk technology can play a large part in satisfying these needs, and potentially can meet many other similar requirements in the future.

Chapter Six

CONCLUSIONS, FINDINGS, RECOMMENDATIONS

Conclusions

Optical disk technology, in products such as LaserVision, Compact Disk, and Compact Disk - Read Only Memory, is a viable technology being used in many application areas today.

Optical disk technology is a very high volume storage media, with at least twenty times the storage capacity of equivalent magnetic media. This capacity is used to both store large amounts of data and to provide storage for large indexes to speed access to the data.

Optical disk technology is one of the most flexible media available for information storage, capable of storing text, video, and audio data on the same device.

Optical disk is a very economical media for storing and distributing large data bases.

Optical disk media is very dependable and long-lived because reading the media with a laser is a non-destructive process, the media requires no special handling, and the media is not subject to damage from electronic or magnetic sources.

Optical disk systems are currently primarily limited to read-only applications, although updating systems (e.g. WORM) have recently become commercially available.

Optical disk technology is still evolving. New media, storage structures, and encoding techniques will be introduced in the near future. Industry standards are in a state of flux, and must be adopted by manufacturers, developers, and implementors before the full potential of the technology can be realized.

Optical disk technology is being used in a variety of education-related applications. Systems are being used to replace film, records, audio cassettes, and video tape for classroom and lecture hall multimedia presentations. Library and research data base applications are available. Future educational uses center on the development of interactive systems

coupling the power of the computer with the low-cost, high-capacity, multimedia capability of optical disk systems.

ACSC is an educational institution interested in using technology to enhance the capabilities of its staff and the learning environment of its students. Several areas in the ACSC environment are potential candidates for the use of optical disk systems.

Findings

Although beyond the scope of this paper, the degree of integration of optical disk systems within the information architecture of an organization should be a high interest item for potential users. Many of the initial applications are stand-alone systems, and the integration of CD-ROM with other computer system components is still being explored by a variety of vendors. Optical disk is only one of a variety of information storage media, each having advantages and disadvantages. The successful implementor must integrate those which provide an effective information environment for the particular organization in question.

The successful exploitation of the capabilities of optical disk depends largely on the computer system which is using it. The key is the ability to intelligently use the massive volume of varied types of data which can be stored on optical disk. It is the capability of the computer system to present the data in a usable form, not the data itself, that is of benefit to the user.

Recommendations

ACSC acquire a small optical disk system for staff education, capability demonstration, and prototyping. The system should interface with the standard microcomputers at the college and should have audio, video, and text capability.

ACSC, in conjunction with Air University, plan, program, and acquire an optical disk system to supplement or replace the current audio/visual systems (film, video tape, etc) in use at the college.

ACSC, in conjunction with Air University, plan, program and acquire an optical disk system for storage, display, and distribution of maps and charts currently available from the Cartographic Information Center.

ACSC, in conjunction with Air University, acquire or develop research support systems using optical disk technology. Cross-indexed copies of video histories, research projects, and DOD/Service regulations are just a few potential candidates for

very large, quick access databases which would greatly benefit faculty and staff.

ACSC plan, program and acquire an optical disk system for use in administrative, word processing, and authoring systems. Databases of document templates, forms, and formats should be built which can be accessed from the standard microcomputers at the college.

ACSC evaluate CD-ROM and other optical disk systems in all future technology enhancement projects involving very large data bases, audio/video capability, or geographic distribution of educational systems or data bases.

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